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# Semi-classical Electrodynamics: A Short Note

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I have previously claimed the key to understanding the numerical value of the fine structure constant is near-field corrections which terminate integrals at low virtual photon energies, thus obverting an infrared divergence common to many QED calculations. I have since switched to a physics-based calculation of the near-field corrections, instead of the previously used educated guess. The relevant equations are presented here.

## Low-order Calculations

A previously reported physics-based calculation of the fine structure constant [1] has been refined. Instead of invoking black-hole physics, my reasoning has been mapped into a more QED-like picture, where virtual vacuum photons are assumed to isotropically scatter from isolated electrons with a cross section of $\pi\bar{\lambda}^2$. In the presence of isolated electrons this scattering process violates conservation of energy and momentum, but is allowed for times given by the time-energy uncertainty principle. In the presence of a pair of electrons, the standard far-field vacuum photons are scattered, and then exchanged and rattle between the pair. The energy in the near field generates a repulsive inverse-square force and defines a numerical value for the fine structure constant $\alpha$~1/137.

As previously reported, the fine structure constant can be expressed as

$$\alpha = \frac{1}{2\pi}\int_0^\infty \frac{f_{\rm nf}^2(\varepsilon)}{\varepsilon(\exp(\varepsilon)-1)}\,d\varepsilon, \tag{1}$$

where $f_{\rm nf}(\varepsilon)$ is the near-field correction factor that scales the isolated scattering cross section to take into account near-field effects associated with the presence of a partner. It is squared because the buildup of the field energy between the pair is controlled by the scattering of far-field virtual photons into the region between the pair, and the scattering of the exchanging photons back into the far field. In the present short note I switch from a previous educated guess of the functional form of the near-field corrections, to a stronger explanation based on quantum mechanical reasoning associated with the overlap of the 3D wave functions of the scattered virtual photons surrounding each electron. The obtained low-order near-field correction is

$$f_{\rm nf} = 1-\exp^2\left(\frac{-\varepsilon^2\pi^2}{2^7}\right). \tag{2}$$

A document showing the derivation needs to wait until my return from an upcoming business trip.

Within my new picture, the anomalous magnetic moment of the electron can be estimated via

$$\frac{g-2}{2} = \frac{1}{4\pi}\int_0^\infty \frac{\exp(-\varepsilon)\,f_{\rm nf}^2(\varepsilon)}{\varepsilon^3}\,d\varepsilon. \tag{3}$$

Using Eqs (1-3) the corresponding calculated quantities are $\alpha$=1/142.08 and (g−2)/2=0.0011423.

## Possible Higher-order Corrections

Higher-order corrections to the proposed near-field based formulation of some QED processes are complex. Arguments exist (to be documented later) that suggest the near-field corrections to higher order might be of the form

$$f_{\rm nf}^* = f_{\rm nf} + (f_{\rm nf})^n \exp^2\left(\frac{-\varepsilon^2\pi^2}{2^7}\right)/2, \tag{4}$$

where $n$ is an unknown value of the order of unity. An estimate of $n$ can be obtained by setting the relationship of our calculated $\alpha$ and (g−2)/2 to that known from QED [2],

$$\frac{g-2}{2} = \frac{\alpha}{2\pi} - 0.328478965579...\left(\frac{\alpha}{\pi}\right)^2 + 1.1812456587...\left(\frac{\alpha}{\pi}\right)^3 - ... \tag{5}$$

The corresponding estimate is $n$=4.750479. This is only ~1 part in $10^4$ away from 19/4. We do not know if any significance should be placed on the closeness of $n$ to 19/4. The corresponding predictions are (g−2)/2=0.001159478 and $\alpha$=1/137.05664. These both differ from the known experimental values by ~1 part in 7000, or ~$3\alpha^2$ (relative). These differences are consistent with the accuracy expected of 4th order calculations with a missing 4th order term. If both Eqs (1) and (3) should be modified by the same 4th order correction scaling factor then this factor can be inferred via 0.001159478 ÷ 0.001159652 = 0.9998498. The corresponding inferred $\alpha$ is 1/137.03605. This differs from the known value by ~1 part in $3\times10^6$ with a relative difference very close to $\alpha^3$. This last result may be fortuitous.

## Conclusions

These results support earlier suggestions that near-field corrections are the key to understanding the numerical value of the fine structure constant. More detailed studies of near-field effects should be pursued.

[1] J. P. Lestone, Los Alamos National Laboratory Report, LA-UR-16-20131 (2016).

[2] T. Aoyama, M. Hayakawa, T. Kinoshita, and M. Nio, Phys. Rev. D **85**, 033007 (2012).